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(54) REGULATING AIR FLOW IN GLASS FIBRE DRAWING

(71) We, PPG INDUSTRIES, INC., a corporation organised and existing under the laws of the Commonwealth of Pennsylvania, United States of America, of One Gateway Center, Pittsburgh, Commonwealth of Pennsylvania 15222, United States of America, (assignee of JOSEPH BERNARD DENT, JR.; DAVID MARVIN LONG; WALTER LEWIS MARTIN, JR. and HOWARD MILTON BENNETT),

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for forming glass fibres.

Glass fiber strands are typically formed by attenuating glass filaments through bushing tips or orifices at the bottom of a heated bushing containing molten glass. The filaments are then passed across the application surface of an applicator where they are coated with a binder and/or size. The filaments are then passed within the groove of a gathering shoe, which is typically a grooved wheel or cylinder formed of a material such as graphite, where the filaments are combined into one or more unified strands. The strand or strands are then collected on a rotating drum or collet as a forming package.

In the past, it has been found advantageous to form the filaments and strand on a first forming level and to collect the thus formed strand on a second forming level. This double level operation has improved the quality of strand produced.

However, a major problem in the formation of quality glass strands remains in controlling the environment at and directly below the bushing. It is well-known that as the filaments are attenuated through the bushing at high speeds, typically ranging from 2,000 to 20,000 feet per minute (609.6 to 6096 meters per minute); that air is aspirated downwardly with the filaments, thus producing a shortage of air at the bushing. This results in turbulent air flow in the area around the bushing as new air attempts to replace that air which has been lost by withdrawal from the bushing area with the attenuated filaments. The turbulent air flow around the bushing results in uneven air flow and thus uneven temperature conditions at the bushing. This combination results in uneven filament diameters being formed and even filament breakouts occurring, the filament diameters being directly affected by any viscosity change in the molten glass which itself is dependent upon any change in temperature. If the turbulence becomes severe enough, breakouts of the filaments can also occur from the air currents alone.

In U.S Patent No. 3,304,163, it has been suggested to locate air conditioning ducts on either side of the bushing and slightly spaced from it. These ducts direct air downwardly with the filaments as they are being formed. While this does increase the air supply in the region around the bushing, it does not provide for the non-turbulent air flow at the bushing which is desired.

By practice of the present invention there may be provided for a more uniform flow of air in the region surrounding the bushing to thus improve both the air flow and temperature environments which are critical to the glass filament formation.

According to the first aspect of the present invention there is provided an apparatus for forming glass fibers comprising a bushing for supplying streams of molten glass, means for attenuating and collecting said streams as continuous fibers, and means for supplying conditioned air, as hereinafter defined, continuously to said bushing at a level with said bushing and perpendicular to said bushing from the front and behind said bushing.

Also according to the present invention there is provided a method of forming glass fibers comprising attenuating glass streams into fibers through a bushing, directing conditioned air, as herein after defined, to said bushing from in front of and behind said bushing at a level with said bushing and perpendicular to the bushing in sufficient amounts to produce a net positive air pressure in the area containing said bushing,

venting the air to a zone having a lower pressure, and collecting the resulting fibers.

By use of this invention the filament formation level of a double level glass fiber strand forming and collecting operation is subjected to a positive air pressure such that any openings in the room containing the filament formation region will not permit extraneous air to enter the room, but will permit only air to flow from the room to the outside. This enables control of the incoming air to the filament formation region.

The expression "conditioned air" as used throughout the specification including the claims is defined as air at a temperature of from 55°F to 65°F and a relative humidity of from 10 to 100 per cent.

Preferably the conditioned air, which is now the only air permitted to enter the room, is provided to the room horizontally from a pair of air-conditioning grills. These grills are located on opposite sides of the room, in front of and behind the bushing. These grills have their vertical and horizontal center lines approximately level with the horizontal and vertical center lines of the bushing. The air flow through these grills is preferably controlled by e.g. louvers and deflectors to provide a constant and laminar flow of air to the bushing from both the front and the rear of the bushing. This air replaces the air which is being drawn downwardly with the filaments and is sufficient to maintain a constant and laminar flow of air at the bushing and thus prevent turbulence in the bushing environment. In addition, this helps maintain a more uniform temperature environment below the bushing and results in the production of more uniform glass filaments and reduced filament breakouts.

Preferably the glass fiber formation system of the present invention includes a separate pair of air grills for each forming position bushing. Both the front and rear grills at each forming position may be individually controlled to increase or decrease the air flow from that grill to its bushing in order to balance the air flow at each position. This is important, since various sized bushings may require different air flow rates and since the positions of necessary equipment adjacent to the bushing may require different air flow rates from the front and rear air grills of a given bushing to maintain a uniform flow rate at the front and rear of the bushing. Thus, the system allows for the operation of various glass fiber bushings on a single glass melting tank with individual air controls over each of them so that each bushing may operate to its maximum potential.

The glass fiber forming system of the present invention will be more fully described by reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a double-level glass fiber forming operation including the air flow system of the present invention;

Figure 2 is a frontal diagrammatic representation of a glass fiber forming operation employing the method and apparatus of the present invention;

Figure 3 is a side elevational view of a cooling manifold as employed in the present invention;

Figure 4 is a cross-sectional view of the manifold as shown in Figure 3; and

Figure 5 is a perspective view of the relation between the cooling manifolds, bushing, intake manifold and recirculation system.

Turning to the figures, it will be readily realized that each forming position is similar in its design and organization. Thus, only a single position will be described, with it being understood that the description will suffice for the balance of the positions.

Glass filaments 10 are attenuated from bushing tips located at the bottom of a heated bushing 12. The bushing 12 is connected to the forehearth 14 of a glass furnace (not shown) through which molten glass 11 is supplied to the bushing 12. The filaments 10 pass across the application surface 16 of an applicator 19. As illustrated, the applicator 19 is a roller applicator with the application surface being a roller 16 being rotated by a motor 20. While the applicator 19 is illustrated as a roller applicator, it is obvious that the applicator 19 could be a e.g. belt applicator or pad applicator. Filments 10 then pass across the face of a gathering shoe 22 where they are combined into a unified strand 24. The strand 24 passes through an opening 26 in the floor 28 of the filament and strand formation level 30 and to the collection level 32. The strand 24 then passes across the face of a rotating spiral 34 wherein it is traversed and collected as a forming package 17 on the winder 36.

The present invention concerns the filaments at the forming level 30. The bushing 12 is supplied air from a pair of grills 40 and 42. Grill 40 is connected to an air transport supply duct 44 and grill 42 is connected to a supply duct 46. These ducts are supplied with conditioned air from ducts 48 and 50, respectively. Preferably, the conditioned air is at a temperature of 60°F. (15.6°C.) and at a relative humidity of about 85 percent.

The air flow from the grill 40 and grill 42 is adjusted such that the velocity of the air at the bushing from both the front and rear of the bushing is between 50 and 150 feet per minute (15.24 and 45.72 meters per

minute), preferably between 50 and 100 feet per minute (15.24 and 30.48 meters per minute). To acomplish this result, the velocity at the grills 40 and 42 is 200 to 500 feet per minute (60.9 and 152.3 meters per minute) and preferably 300 to 400 feet per minute (91.4 and 121.9 meters per minute). These velocities may be equal from both the front and rear grills 40 and 42. However, typically the velocity is somewhat higher from the rear grill 40, since equipment necessary to the operation of the bushing, such as electric bus bars and transformers (not shown), are located in this area. The velocity of 50 to 150 feet per minute (15.24 and 45.72 meters per minute) reaching the bushing both from the front and rear produces laminar flow at the bushing rather than the turbulent flow typically encountered in the past. Typically, flow rates of the air entering from grills 40 and 42 are 300 to 400 cubic feet per minute (8.5 to 11.3 cubic meters per minute) with slightly more total air typically being released from the front grill 42, to aid in the comfort of the operator working on the forming level.

Due to the damp conditions at the bushing, both from the applicator 19 and from cooling pre-pad sprays (not shown) directly below the bushing 12, the relative humidity at the bushing 12 is approximately 100 percent, a saturated condition.

The forming positions are separated from one another by separator plates 52. Connected to these plates are cooling panels 54. Figure 3 illustrates one of the cooling panels or manifolds 54. The manifold 55 is substantially identical to the manifold 54 except for the locations of the inlets and outlets along its length.

The manifold 54 has a plurality of inlet sections 142 and 143 and a plurality of return sections 144. The inlet sections 142 are connected at their intake by connectors 146 to the supply of cooling fluid for the manifold. This cooling fluid may be e.g. water or DOWTHERM®. Chilled recirculating water is the preferred cooling fluid. Along the length of the inlet sections 142 are outlets 148. These outlets are connected by connectors 150 to the inlets of the various elements within the bushing area apparatus which require cooling by the cooling fluid. These elements include a cooling ring embedded in the refractory material surrounding the platinum or platinum-rhodium bushing, the terminal clamps electrically connecting the bushing to its electrical power supply, cooling panels located in front of and behind the bushing, and the fin coolers. Some spare outlets 148 may additionally be located along the inlet sections 142 which may be sealed when not utilized.

The inlet section 143 is connected at 152 to a source of high pressure water, preferably from 70 to 200 pounds per square inch (476,190 to 1,360,544 pascals), to be supplied through outlets 154 to such locations as the prepad sprays the forming level washdown hoses. Manifold 55 may or may not include this inlet section, depending upon the needs of a given forming position. Preferably, both manifolds 54 and 55 include this section.

The cooling fluid passing through the outlets 148 is directed to the elements preciously mentioned. After passing through these elements, the cooling fluid re-enters the manifold 140 through its outlet sections 144. The sections 144 are supplied with inlets 156 having connectors 158. As with the inlet sections 142, spare inlets 156 may be provided where desired which are sealed when not employed. The outlet sections 144 have outlets 160 through which the cooling fluid exits the manifold 140 to be returned to the supply of cooling fluid, such as a recirculating water system. Manifold 55 acts identically to manifold 54.

While not absolutely necessary, it is desirable that each return manifold section 144 have a single inlet 156 connected at one time. This is desirable so that the operator can easily detect a clogged line by noting the lack of output from a given outlet 160, as will be described below. It is also highly desirable that similar inlets 148 and 156 are attached to similar cooling elements at each forming position. This adds to the ease of serviceability of the system for the operator.

It is further desirable to equalize the amount of cooling provided by each manifold 54 and 55 for a given forming position by careful selection of the elements connected to each outlet 148 and inlet 156. This helps provide a more uniform cooling amount for each manifold in its operation as a cooling manifold for the sides of the bushing to provide a more uniform temperature environment below the bushing.

As can be seen in Figure 4, the inlet sections 142 and 143 are preferably larger in cross section and thus in volume than the return or output sections 144. This is preferable since the inlet sections 142 are normally connected to more than one element while the outlet sections 144 are normally connected only to a single element each.

The manifolds 54 and 55 are formed of a material which can withstand the hot and damp environment below the bushing. A suitable material is stainless steel. In physical appearance the manifolds are generally flat on their outer surface and that surface is parallel to the position divider on which it is mounted.

Thus, as cooling fluid flows through the manifolds 54 and 55 on its way to and from

the various elements of the bushing apparatus, the manifold 54 acts as a cooling manifold for the sides of partitions between the bushings and for the environment around the bushing. At the same time, the fluid flowing through the elements of the bushing apparatus between the outlets 148 and the inlets 156 provides cooling to these elements. In addition, the amount of hose necessary to connect the elements to their necessary fluid supply is reduced thus resulting in a more open area below the bushing thus allowing increased air flow and aiding in providing a more uniform environment below the bushing.

In Figure 5, the manifold 54 is illustrated in perspective. Above the manifold 54 is the bushing 10, with its fin coolers 170 and its electrical terminal clamp 176. A front bushing cooling manifold 172 is illustrated connected to an inlet section 142 of the manifold 54 through line 174. This is typical of the connections to both inlets and outlets.

Manifold 178 is located behind the cooling manifold 54. Its valves 180 are connected to the inlet section connections 146 and supply the cooling fluid for the system. A similar manifold supplies manifold 55.

Lines 182 are the exit lines from the output sections 144. They are connected to outlets 160. By observing the fluid flow from the lines 182 into trough 184 an operator can immediately note a clog in the system. Preferably, each forming position will have all of its lines arranged identically or as near as possible so that the operator can immediately note the location of a clog.

The trough 184 is connected to a cooling fluid recirculation system (not shown) to recycle the cooling fluid to intake manifold 178.

The air flowing from the grills 40 and 42 reaches the bushing 12, as previously mentioned, in laminar flow from both the front and the rear. As the air reaches the bushing, it is aspirated downwardly with the filaments 10 and the majority of the air passes through the opening 26 to the collecting level 32. Some of the air strikes the floor 28. In the past, this air has "bounced" off the floor 28 and back up into the bushing area, again creating a turbulent flow. However, according to the present invention, a plate 60 is provided which is connected to a stand at 62 for the applicator 19. This plate 60 has an opening at its bottom which allows air "bouncing" off the floor 28 to escape through the opening between it and the floor 28. The vent opening may range in height from 3 to 8 inches (7.62 to 20.32 centimeters). Preferably, this opening is about 5 inches (12.70 centimeters) in height. This air is thus vented away from the bushing region and thus does not return to the area directly below the bushing to cause turbulent air flow therein. The air returns rearwardly towards the grill 40 and is aspirated back to the air stream flowing towards the bushing 12 in laminar flow. Thus, turbulent air flow at the bushing has been substantially reduced or eliminated.

The air flowing through the opening 26 passes downwardly with the strand 24 to the collet 36. Collet 36 is rotating in a clockwise direction which produces a negative air pressure to its right and forces the air along its right and through the waste chute 66 to the waste collection area 70 which is connected to the recirculation system for the conditioned air (not shown).

As previously mentioned, the filament and strand formation region is designed such that extraneous air does not enter the system. The air flowing through the grills 40 and 42 is in a sufficient quantity to produce a positive air pressure within the room containing the filament and strand forming equipment. This positive air pressure is slight, being 0.05 to 0.075 pounds per square inch (340.1 to 510.2 pascals) above atmospheric pressure, however, it is sufficient to exclude extraneous air from the fiber forming room. Due to the positive air pressure, air cannot enter the fiber forming room from openings such as doors on the end of the room and the opening 26 between the room 30 and the strand collection region 32. Thus, air will flow from filament formation region 30 through these openings to the other region and consequently only the conditioned air through the grills 40 and 42 reaches the bushing region.

The present invention will now be further illustrated by way of the following Example:—

Example

DE-150 bushing having 400 orifices each were operated for a period of 35 days at a speed of approximately 14,000 feet per minute (4263 meters per minute). The bushings were operated in an enclosed air pressurized forming region having conditioned air from grills 40 and 42 flowing horizontally across the bushing at a velocity of approximately 50 feet per minute (15.4 meters per minute). The bushings are designed to wet pull 36.9 pounds of glass per hour (16.7 kilograms per hour) when operating efficiently.

During the 36 day span, the bushings averaged 37.0 pounds per hour (16.8 kilograms per hour), a 100.3 percent job efficiency. During this time period, the percentage of calldowns, i.e. the percentage of complete forming packages produced without strand breakage was 63.8 percent.

In comparison, identical DE-150 bush-

ings were operated during the same time period at the same rate on another double-level forming operation without the air flow system of the present invention. During the 35 day period, the average wet pull per hour for these bushings was 30.7 pounds per hour (13.9 kilograms per hour). This converts to a job efficiency of 83.1 percent. During this same time period, the percentage of calldowns was 33.9 percent.

Thus, the tank employing the present invention showed an increase of both the amounts of glass produced and the amount of packages formed without a breakage occurring. This illustrates the improvement in the quality of glass strand produced by the employment of the present invention.

While this invention has been described with reference to a specific embodiment thereof, it is not intended to be so limited thereby except as set forth in the accompanying claims.

WHAT WE CLAIM IS:—

1. An apparatus for forming glass fibers comprising a bushing for supplying streams of molten glass, means for attenuating and collecting said streams as continuous fibers, and means for supplying conditioned air, as hereinbefore defined, continuously to said bushing at a level with said bushing and perpendicular to said bushing from the front and behind said bushing.

2. An apparatus as claimed in claim 1 wherein the means for supplying conditioned air, as hereinbefore defined, continuously to said bushing comprising an air-conditioning system having grills with their center lines located approximately level with the center lines of said bushing both in front of and behind the bushing.

3. An apparatus as claimed in claim 2 wherein a plurality of bushings are supplied from a common supply system.

4. An apparatus as claimed in any one of claims 1 to 3 further comprising means for adjusting the amount of air supplied to said bushings from in front and behind said bushing separately.

5. An apparatus as claimed in any one of claims 1 to 4 wherein said means to supply air to said bushing is adjusted to supply air at a velocity, at the bushing, of between 50 and 150 feet per minute (15.24 and 45.72 meters per minute).

6. An apparatus as claimed in any one of claims 1 to 5 comprising means for sealing the region containing said bushing such that a positive air pressure is created in said region.

7. A method of forming glass fibers comprising attenuating glass streams into fibers through a bushing, directing conditioned air, as hereinbefore defined, to said bushing from in front of and behind said bushing at a level with said bushing and perpendicular to the bushing in sufficient amounts to produce a net positive air pressure in the area containing said bushing, venting the air to a zone having a lower pressure, and collecting the resulting fibers.

8. A method as claimed in claim 7 further comprising adjusting the amount of air supplied to said bushing from in front of and/or behind said bushing.

9. A method as claimed in claim 7 or 8 wherein conditioned air, as hereinbefore defined, is directed to a plurality of bushings from a common supply source.

10. A method as claimed in any one of claims 7 to 9 wherein said air is supplied at a velocity, at the bushing, of between about 50 and 150 feet per minute (15.24 and 45.72 meters per minute).

11. A method as claimed in any one of claims 7 to 10 further comprising producing a positive air pressure in a region surrounding the bushing to prevent extraneous air from entering the region.

12. A method of forming glass fibers comprising attenuating glass streams into fibers from a bushing containing molten glass and collecting the resulting fibers in strand form and wherein the bushing is positioned in a first room located above a second room wherein the strand is collected, air is applied to an air transport duct at a temperature of from 55° to 65°F. (12.8 and 18.3°C.) at a relative humidity of from 70 to 100 percent, air is forced from the air transport duct through a plurality of grills positioned in front of and in back of each bushing in said first room, the air from each of said grills is directed horizontally across the room to said bushings opposite said grills at a velocity of from 300 to 400 feet per minute (91.4 to 121.9 meters per minute) to provide at each of the bushings a velocity of air of from 50 to 150 feet per minute, a positive pressure of from 0.05 to 0.075 pounds per square inch (340.1 to 510.2 pascals) with respect to said second room is established in said first room and the conditioned air is directed, as it reaches each said bushing, downwardly with the fibers being attenuated and into said second room.

13. A method as claimed in claim 12 wherein said air temperautre is 60°F. (15.6°C.).

14. A method as claimed in claim 12 or 13 wherein said relative humidity is about 85 percent.

15. A method as claimed in any one of claims 12 to 14 wherein said velocity of air at each bushing is about 50—100 feet per minute (15.24 and 30.48 meters per minute).

16. A method as claimed in claim 15 wherein said velocity of air at each bushing

is 50 feet per minute (15.24 meters per minute).

17. An apparatus for forming glass fibers substantially as hereinbefore described with reference to the accompanying drawings.

18. An apparatus for forming glass fibers substantially as hereinbefore described with reference to the Example.

19. A method of forming glass fibers substantially as hereinbefore described with reference to the accompanying drawings.

20. A method of forming glass fibers substantially as hereinbefore described with reference to the Example.

21. Glass fibers whenever formed by a method as claimed in any one of claims 7 to 16, 19 or 20.

22. A method of forming glass fibers as claimed in any one of claims 7 to 16 which comprises attenuating filaments through bushing tips in a busing, providing said air to said bushing, applying a binder and/or size to the filaments and gathering the filaments into a unified strand on a first forming level, passing the strand through an opening provided in the floor of the first level to a second level, aspirating a majority of said air stream downwardly with said filaments and strand through said opening, collecting the strand on the second level, and venting the portion of said air stream which strikes the floor of said first level and thus does not pass through said opening rearwardly from a region below the bushing to prevent return of the air striking the floor to the region directly below the bushing to thereby prevent turbulent air flow below the bushing.

23. A method of forming glass fibers as claimed in any one of claims 7 to 16, which additionally comprises cooling the sides of the environment surrounding and below the bushing and the elements adjacent the bushing by passing a cooling fluid through a pair of cooling manifolds located on side partitions separating adjacent bushings, said manifolds being below the bushing on said partition, connecting said manifolds to said elements, passing said fluid from the manifolds through said elements, returning said fluid from said elements to said manifolds, and flowing said fluid through said manifolds to cool said environment and said elements with the same cooling fluids.

24. An apparatus as claimed in any one of claims 1 to 6, which comprises a bushing having a plurality of bushing tips through which filaments are attenuated from molten glass contained in the bushing, means for applying binder and/or size to the filaments, a gathering shoe for combining the filaments into a unified strand, means for collecting the strand, a pair of cooling manifolds, one being located on either side and below said bushing on side partitions positioned to separate adjacent bushings, said manifolds including inlet sections and outlet sections, said inlet sections being connected to a supply of cooling fluid at one end and to elements associated with said bushing to be supplied with said cooling fluid along its length, said outlet sections being connected along their length to said elements and at one end to the return for said cooling fluid, said manifolds being designed and arranged to cool the environment surrounding and below the bushing while providing cooling fluid to the elements associated with the bushing.

25. An apparatus as claimed in any one of claims 1 to 6, comprising a bushing having a plurality of bushing tips through which filaments are attenuated from molten glass contained in the bushing, an applicator having a surface across which said filaments pass, a gathering shoe for combining the filaments into a unified strand, a collet for winding the strand into a forming package and a pair of cooling manifolds located on either side of and below the bushing on partitions separating adjacent bushings, said manifolds comprising inlet sections and outlet sections, said inlet sections being connected to a plurality of elements around said bushing in fluid flow relation to allow a cooling fluid to flow through said manifolds and to said elements, said outlet sections each being connected in fluid flow relation to a single element to allow cooling fluid to flow from said element to its cooling sections, said inlet sections being connected to a supply of cooling fluid and said outlet sections being connected to the return for said cooling fluid to provide cooling to the environment surrounding and below the bushing and to the elements surrounding the bushing.

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1583265 COMPLETE SPECIFICATION

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Sheet 1

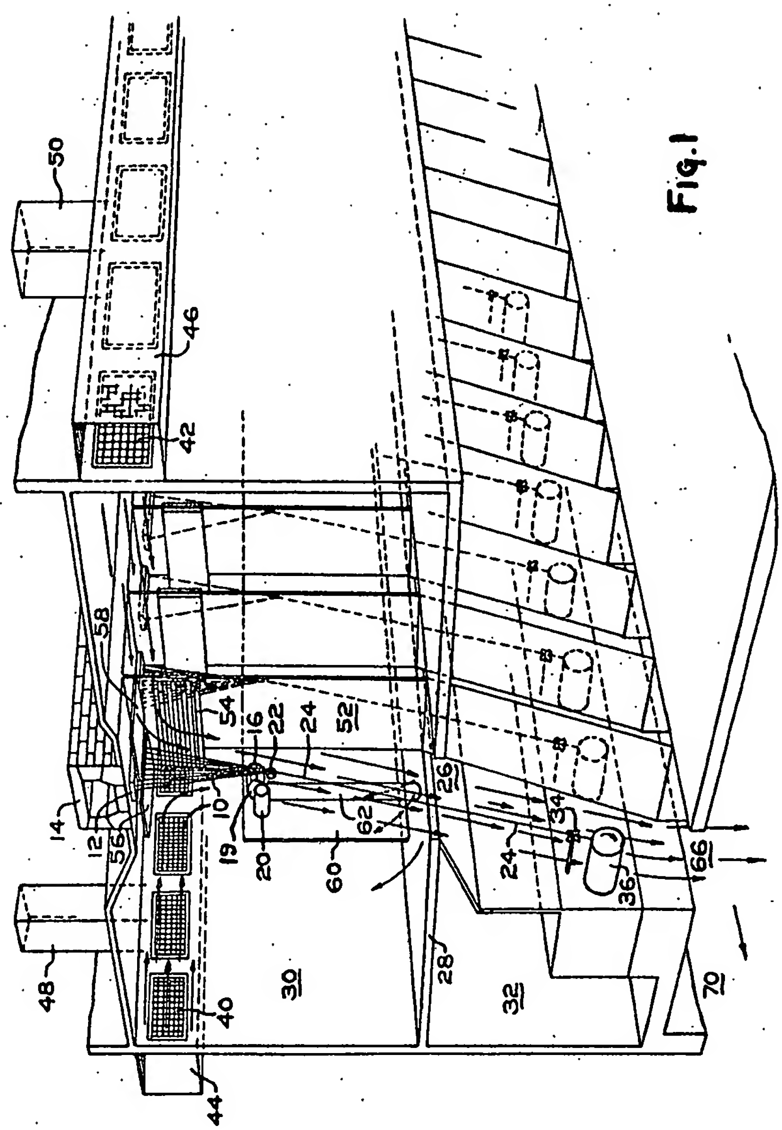

Fig. 1

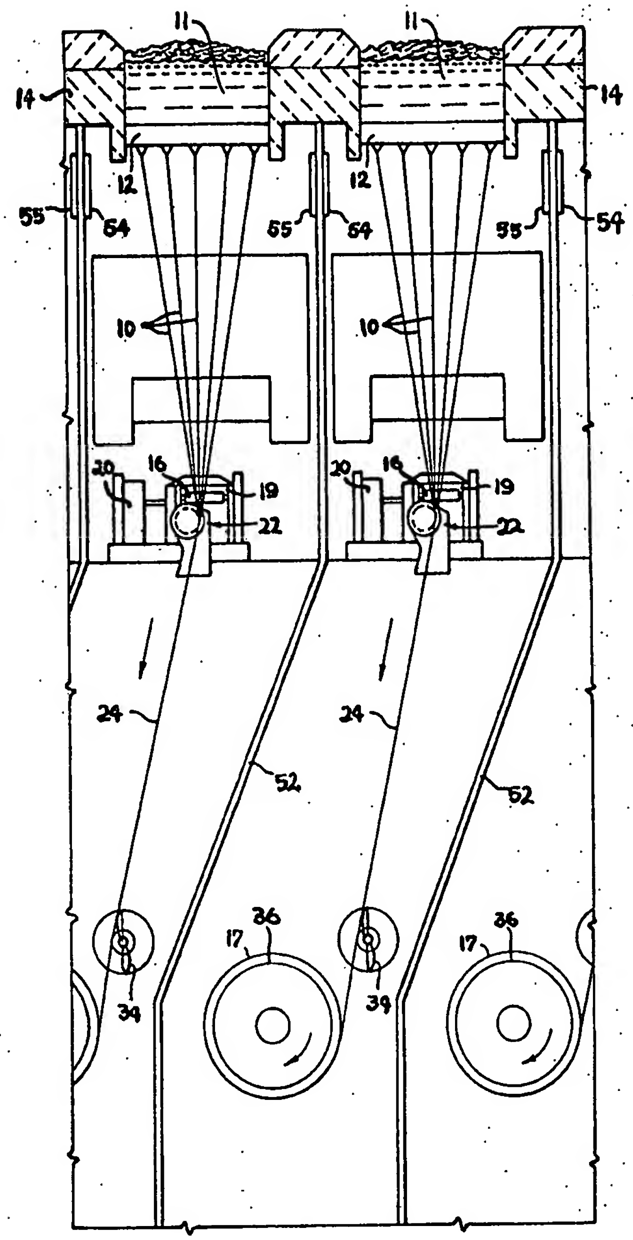
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FIG. 2

1583265 COMPLETE SPECIFICATION

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Sheet 3

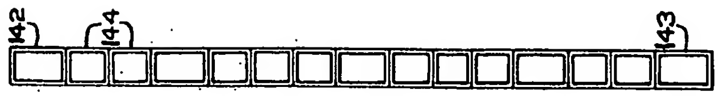

FIG.4

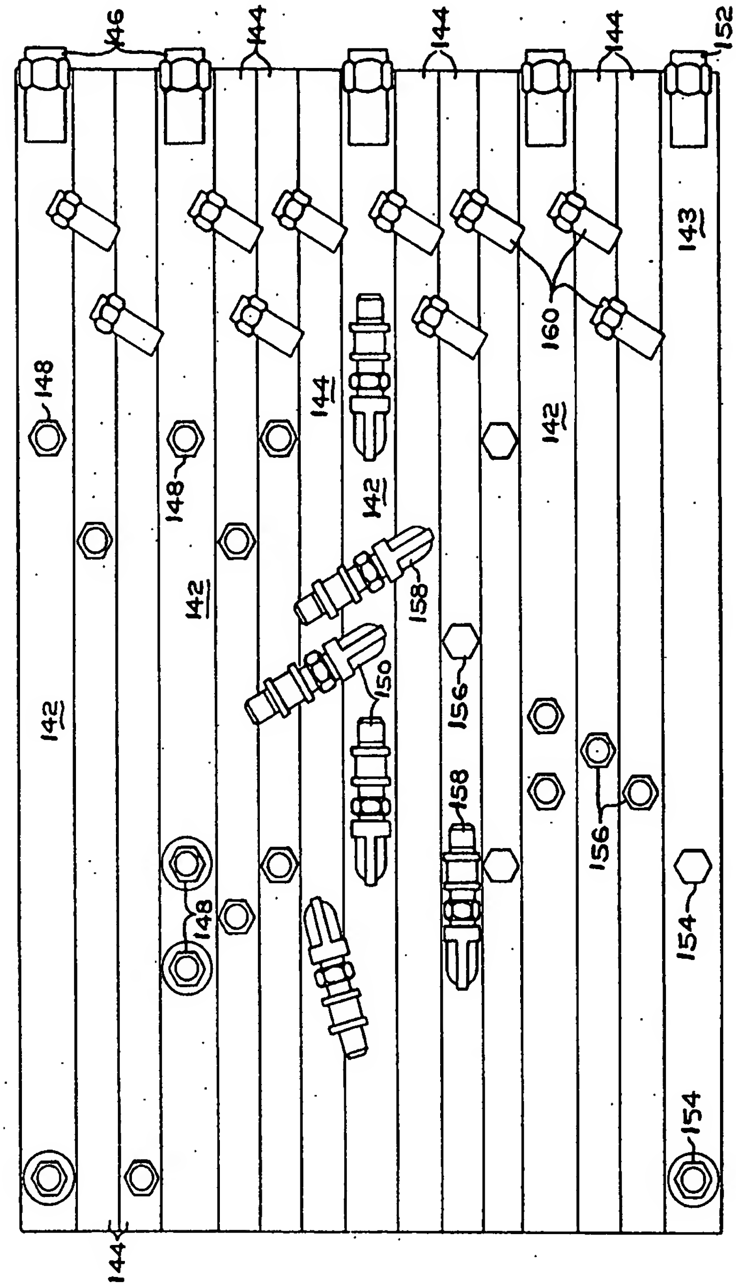

FIG.3

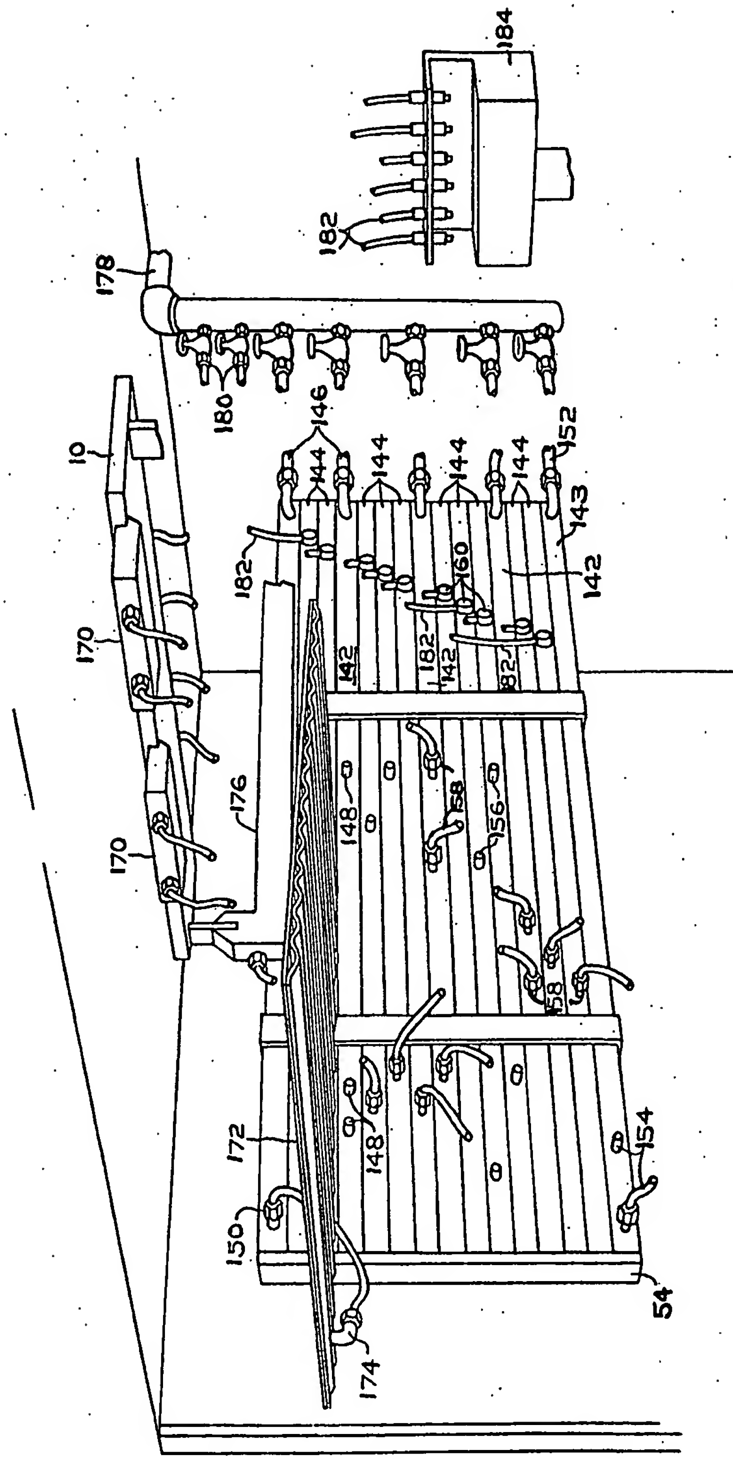
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FIG.5